TECHNICAL NOTES

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

No. 916

THE EFFECT OF THE TYPE OF SPECIMEN ON THE SHEAR STRENGTHS OF DRIVEN RIVETS

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SUMMARY

Tests of various types of riveted joint composed of 24S-T sheet and 1/8-inch A17S-T rivets have been made in order to determine the effects of specimen type on shear strengths. The results indicated that there was only slight variation in shear strength with considerable variation in the types of specimen. Lap joints gave a shear strength about 2 percent greater than joints with a single-butt strap and about 4 percent greater than double-shear, double-butt-strap joints. Joints in which a single rivet resists the shearing forces gave about 0.5 percent greater shear strengths than joints with two or more rivets. The double-shear joints generally resisted deformation better than other types of joint.

INTRODUCTION

Several types of rivet shear specimen have been utilized in various investigations of the shear strengths of driven rivets, but there is some question as to possible differences in results obtained from one type of specimen as compared to those from another type of specimen that involves identical materials. An investigation to determine the effects of specimen type on shear strengths could also furnish data concerning the deformations under load of the various types of joint. Such information on types of joint which are representative of practices in the aircraft industry would be of considerable value.

The object of this investigation was to determine the effect of a number of different types of specimen on the shear strengths of driven rivets and also on the deformation characteristics of the various joints.

SPECIMENS

The specimens for this investigation were made using 1/8-inch diameter A17S-T rivets and 24S-T sheet. The sheet thickness for single-shear joints was 0.064 inch, and for the double-shear joints a combination of 0.064-inch and 0.128-inch thicknesses was used. All rivet holes were drilled with a No. 30 drill (0.1285 in.). All rivets were taken from the same batch and were cold driven with flat heads of approximately 3/16-inch diameter. The driving pressure was about 2100 pounds. Ten riveted panels were prepared for this investigation. Each panel consisted of four identical specimens of one of the ten types shown in figure 1. There were three panels of single-shear lap joints, one each with one, two, and three rivets in line; three panels of single-shear, single-butt-strap joints, one each with one, two, and three rivets in line on either end of the joint; two panels of single-shear, single-butt-strap joints, one each with two rows of one or two rivets in line; and two panels of double-shear, double-butt-strap joints, one each with one or two rivets in line. The panels were numbered consecutively from 1 to 10. For all specimens the edge distances in the direction of stressing were twice the nominal diameter of the rivet, the pitch of rivet lines was four diameters, and the gage for the specimens with double rows of rivets was six diameters.

TESTS

All specimens were tested in the 50,000-pound capacity Southwark-Tate-Emery universal testing machine, serial no. 50-TE-162, using the proper load range for the particular type of specimen tested. The tests were performed 7 to 10 days after the rivets had been driven. Slip in the joints was measured on a 2-inch gage length with the use of a dial gage with points set at right angles to the direction of travel of the stem. These measurements were made on both edges of each specimen for load increments of 25 pounds per rivet for the single-shear specimens and 50-pound increments per rivet for the double-shear specimens.

DISCUSSION OF RESULTS

The maximum loads for each specimen and the corresponding shear strengths per rivet are listed in table I. All specimens failed by shearing the rivets. The greatest shear strengths were obtained from the lap joint with a single rivet (type 1), although its margin of strength over the next strongest joint (type 3) was quite small. As a group, the lap joints gave greater shear strengths than the joints with single-butt straps and both gave greater strengths than the double-shear, double-butt-strap joints. The difference in strength between the strength of single-shear and double-shear joints is consistent with the results of previous tests. The spread between the average values was quite small, the maximum average value obtained for any specimen type being 36,500 pounds per square inch, and the minimum 34,925 pounds per square inch. The over-all average was 35,640 pounds per square inch, which is 32 percent greater than the present design value of 27,000 pounds per square inch permitted by ANC-5.

Average load-slip curves for the various types of specimen are shown in figure 2. For comparative purposes all the curves are plotted from the same origin in figure 3. From this comparison it is evident that, for a given load per rivet, types 9 and 10 (double-shear, double-butt-strap joints) were more resistant to deformation than any other type, and that type 1 (lap joint, single rivet) was the stiffest of the single-shear joints. Similarly joints in which a single rivet was sheared showed less deformation than joints in which two or more rivets resisted the shearing forces.

It will be noted in figure 3 that, for a given load per rivet, the lap joints were all more resistant to deformation than the joints with single-butt straps. This condition exists because the lap joints had only one shear surface on which slippage could occur, whereas the joints with single-butt straps had two surfaces on which slippage could occur. In other words, each single-butt-strap joint represents two separate lap joints. Similarly each double-butt-strap joint can be thought of as two separate joints. Following this line of reasoning, figure 4 has been prepared in which the deformations of the single- and double-butt-strap joints have all been divided by 2; whereas the deformations of the lap joints are plotted without reduction. Furthermore the ordinates

are expressed in terms of shear stress rather than load in pounds per rivet to take into account the extra shear plane in the double-shear joints. A comparison of this figure with figure 3 indicates that this method of plotting has grouped the curves much more closely together, an indication that some of the spread in the curves in figure 3 can be explained by the foregoing reasoning.

The following tabulation gives the comparative ratings of the various specimen types on the basis of both shear strength and resistance to deformation:

Specimen type	Description	Shear strength order	Resistance to deformation order (a)
1	Lap joint, single rivet	1	3
2	Lap joint, two rivets	3	5
3	Lap joint, three rivets	2	4
4	Single-butt-strap joint, two rivets	6	8
5	Single-butt-strap joint, four rivets	8	10
6	Single-butt-strap joint, six rivets	5	9
7	Single-butt-strap joint, two rows, four rivets	7	7
8	Single-butt-strap joint, two rows, eight rivets	4	6
9	Double-butt-strap joint, two rivets	9	1
10	Double-butt-strap joint, four rivets	10	2

[a]From figure 3, using a load per rivet of about 300 pounds.

CONCLUSIONS

The results of tests on various types of riveted joint composed of 24S-T sheet and 1/8-inch A17S-T rivets lead to the following conclusions:

1. The average shear strength, based on the area of the hole, of the 1/8-inch A17S-T rivets tested in this investigation was 35,640 pounds per square inch, a value that is above the average shear strength expected for such rivets, according to results of previous tests, and is 32 percent greater than the 27,000 pounds per square inch design value permitted by ANC-5.

2. There was only a small variation in shear strength in the individual tests regardless of considerable variations in the types of specimen. The lowest individual value was 34,500 pounds per square inch obtained on a double-butt-strap joint with four rivets, and the highest individual value was 36,800 pounds per square inch obtained on a lap joint with a single rivet.

3. Lap joints gave an average shear strength about 2 percent greater than joints with a single-butt strap and about 4 percent greater than double-shear, double-butt-strap joints.

4. Riveted joints in which only one rivet resisted the shearing forces gave about 0.5 percent greater shear strengths than joints in which two or more rivets resisted the shearing forces.

5. In general, the double-shear joints resisted deformation better than other types of joint.

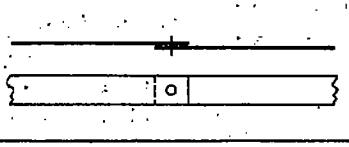
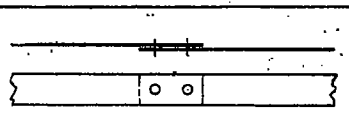
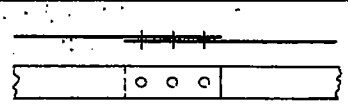
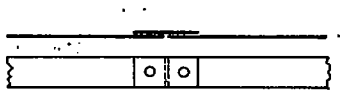
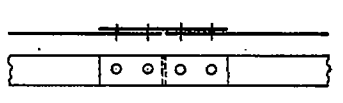
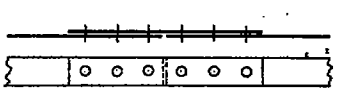
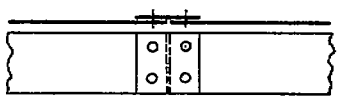
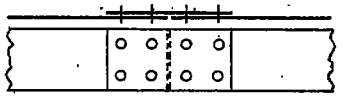
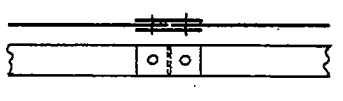
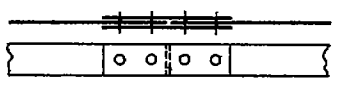
Aluminum Research Laboratories,
Aluminum Company of America,
New Kensington, Pa., May 16, 1942.

BIBLIOGRAPHY

Anon.: Strength of Aircraft Elements. ANC-5, Army-Navy-Commerce Committee on Aircraft Requirements, U. S. Govt. Printing Office, Oct. 1940.

TABLE I

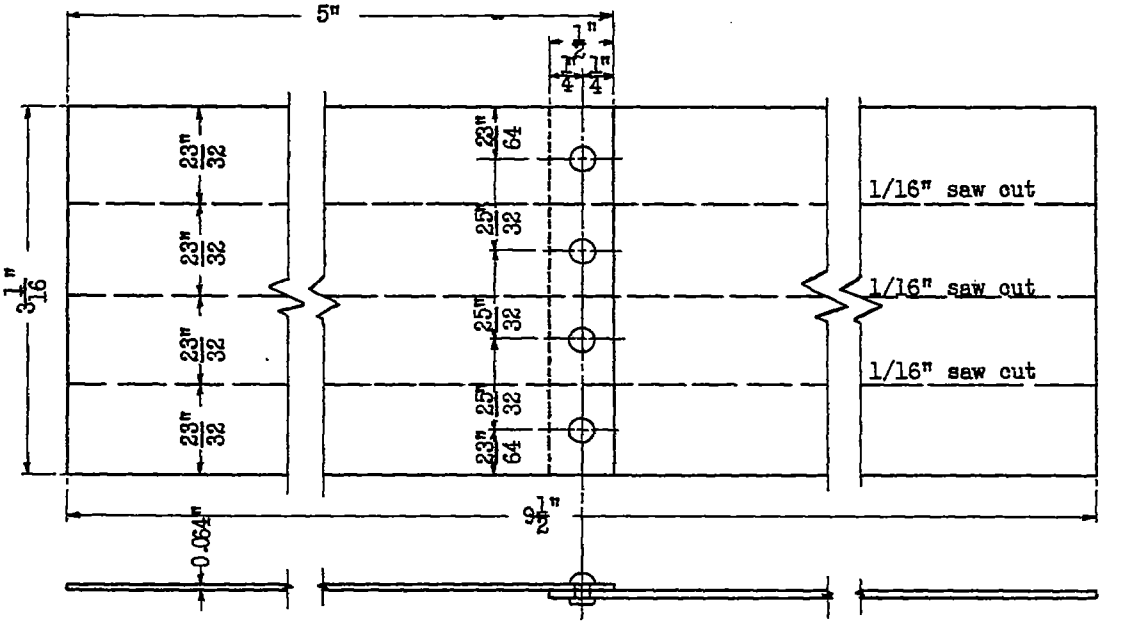
THE EFFECT OF THE TYPE OF SPECIMEN ON THE SHEAR STRENGTHS OF DRIVEN RIVETS

Type of riveted joint	Sketch	Specimen	Maximum Load (lb) (a)	Shear strength (lb/sq in.) (b)
Lap joint with single rivet		1-1	473.5	36,400
		1-2	473.0	36,400
		1-3	479.0	36,800
		1-4	472.5	36,400
		Average	474.5	36,500
Lap joint with 2 rivets in line		2-1	920.0	35,400
		2-2	955.0	36,700
		2-3	940.0	36,200
		2-4	955.0	36,700
		Average	942.5	36,250
Lap joint with 3 rivets in line		3-1	1395.0	35,800
		3-2	1415.0	36,300
		3-3	1430.0	36,600
		3-4	1430.0	36,600
		Average	1417.5	36,325
Single-butt-strap joint with 2 rivets		4-1	453.5	34,800
		4-2	464.0	35,700
		4-3	459.5	35,400
		4-4	458.0	35,200
		Average	459.0	35,275
Single-butt-strap joint with 4 rivets		5-1	915.0	35,200
		5-2	920.0	35,400
		5-3	920.0	35,400
		5-4	905.0	34,800
		Average	915.0	35,200
Single-butt-strap joint with 6 rivets		6-1	1385.0	35,500
		6-2	1380.0	35,400
		6-3	1395.0	35,800
		6-4	1395.0	35,800
		Average	1389.0	35,625
Single-butt-strap joint with 4 rivets in 2 rows		7-1	915.0	35,200
		7-2	920.0	35,400
		7-3	915.0	35,200
		7-4	915.0	35,200
		Average	916.0	35,250
Single-butt-strap joint with 8 rivets in 2 rows		8-1	1845.0	35,500
		8-2	1880.0	36,200
		8-3	1890.0	36,400
		8-4	1870.0	36,000
		Average	1871.0	36,025
Double-butt-strap with 2 rivets		9-1	910.0	[c]35,000
		9-2	910.0	[c]35,000
		9-3	900.0	[c]34,600
		9-4	920.0	[c]35,400
		Average	910.0	[c]35,000
Double-butt-strap joint with 4 rivets		10-1	1815.0	[c]34,900
		10-2	1845.0	[c]35,500
		10-3	1815.0	[c]34,900
		10-4	1790.0	[c]34,400
		Average	1816.0	[c]34,925

[a] All specimens failed by shearing the rivets.

[b] Shear area of one rivet = $(0.129^2 \times \pi/4) = 0.0130$ sq. in.

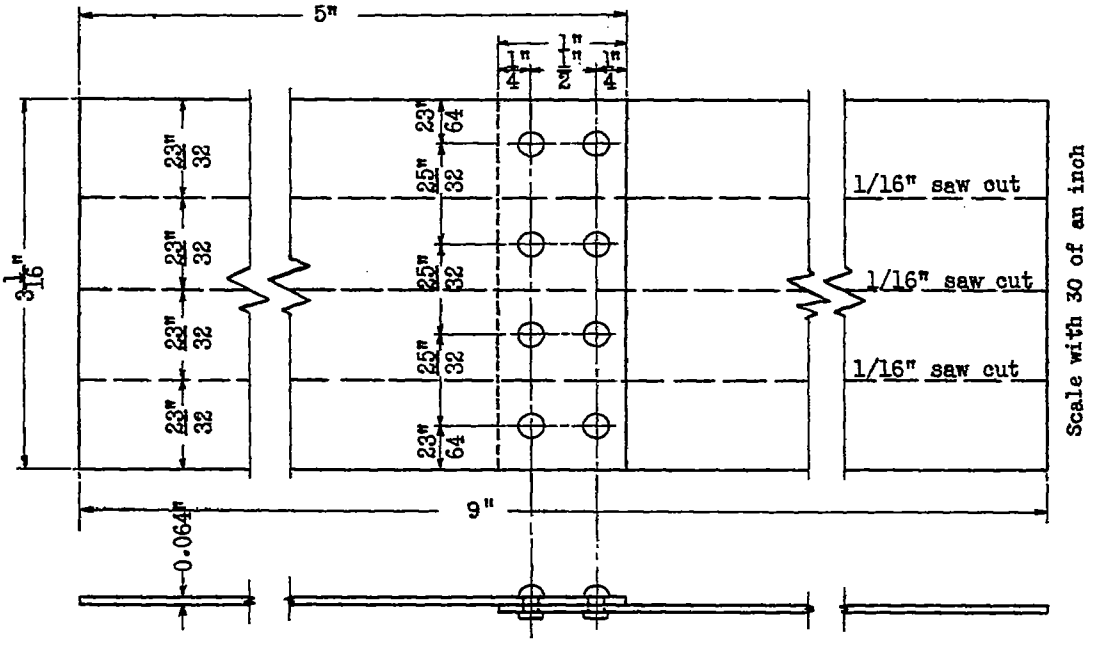
[c] Single shear values determined from double shear tests.



PANEL OF SINGLE-SHEAR TEST SPECIMENS

1/8" Rivets
All Holes - No. 30 Drill (0.1285 in.)
Specimen Type 1

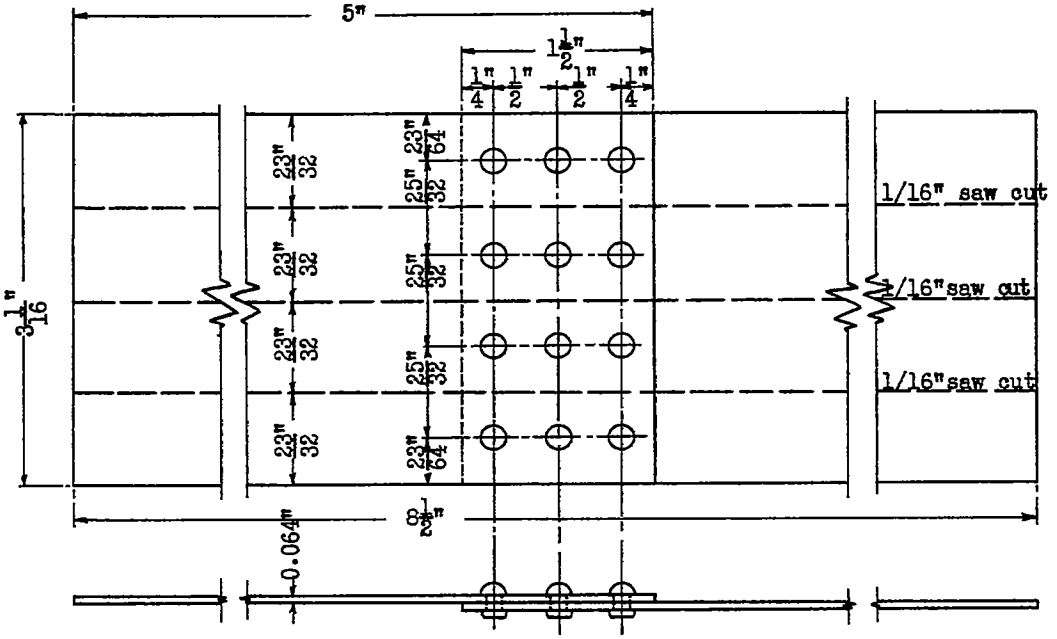
Figure 1(a to j)



PANEL OF SINGLE SHEAR TEST SPECIMENS

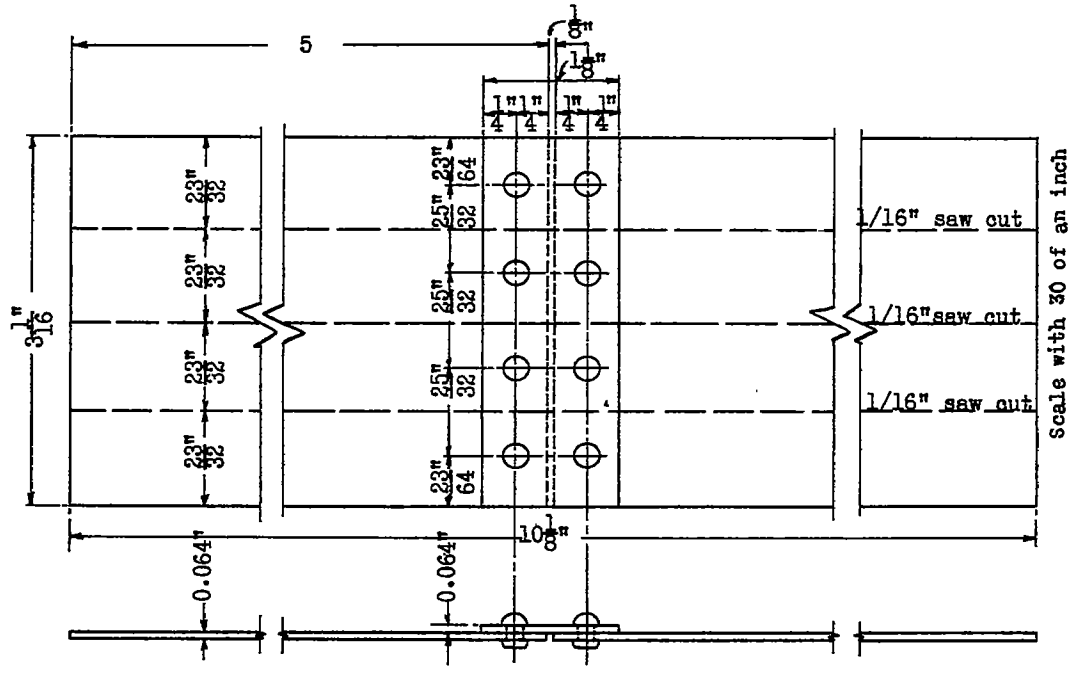
1/8" Rivets
All Holes - No. 30 Drill (0.1285 in.)
Specimen Type 2

Figure 1 (b)



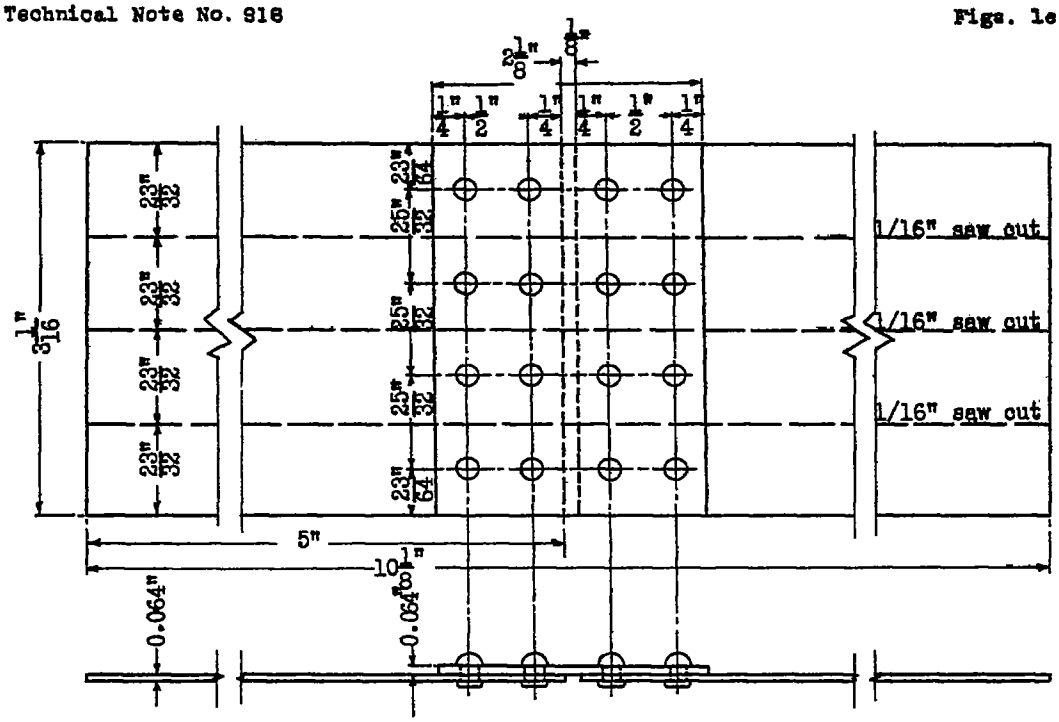
PANEL OF SINGLE SHEAR TEST SPECIMENS

Figure 1(c) 1/8" Rivets
All Holes - No. 30 Drill (0.1285 in.)
Specimen Type 3



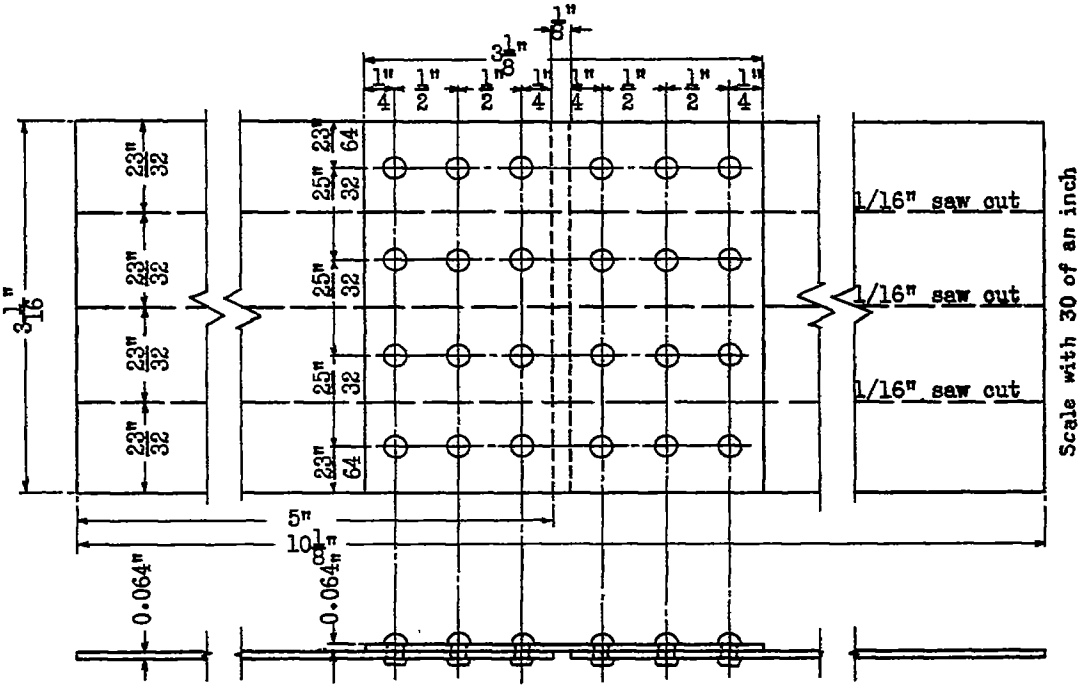
PANEL OF SINGLE SHEAR TEST SPECIMENS

Figure 1(d) 1/8" rivets
All Holes - No. 30 Drill (0.1285 in.)
Specimen Type 4



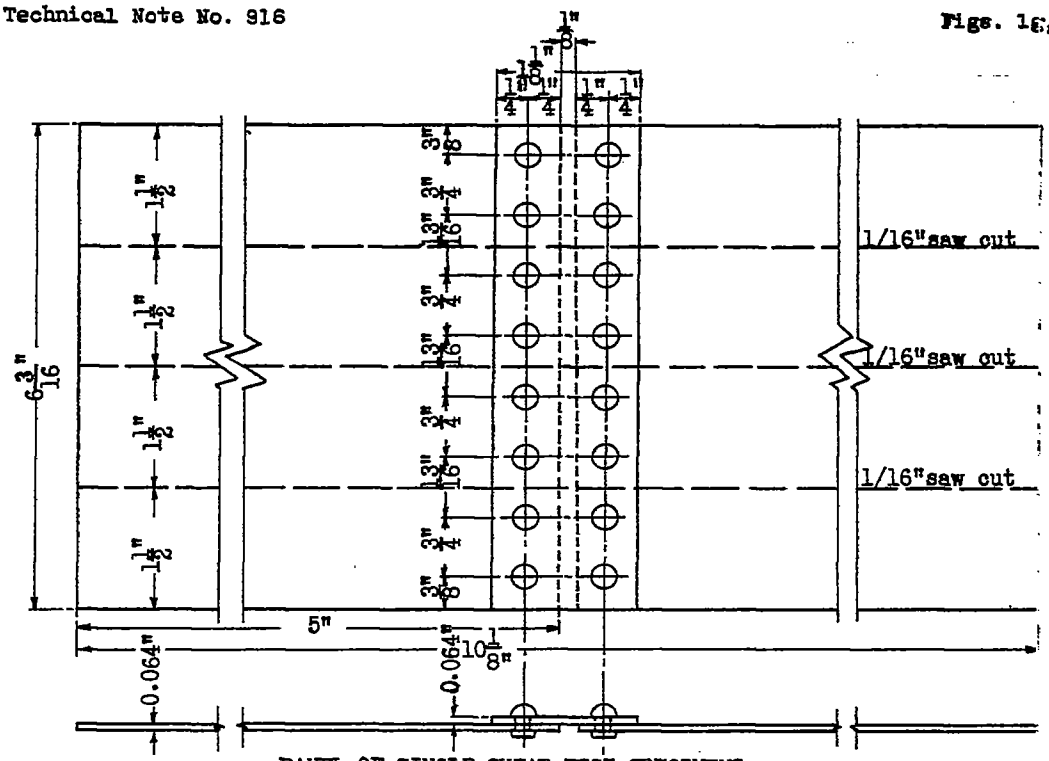
PANEL OF SINGLE SHEAR TEST SPECIMENS

Figure 1(e) 1/8" rivets
All Holes - No. 30 Drill (0.1285 in.)
Specimen Type 5



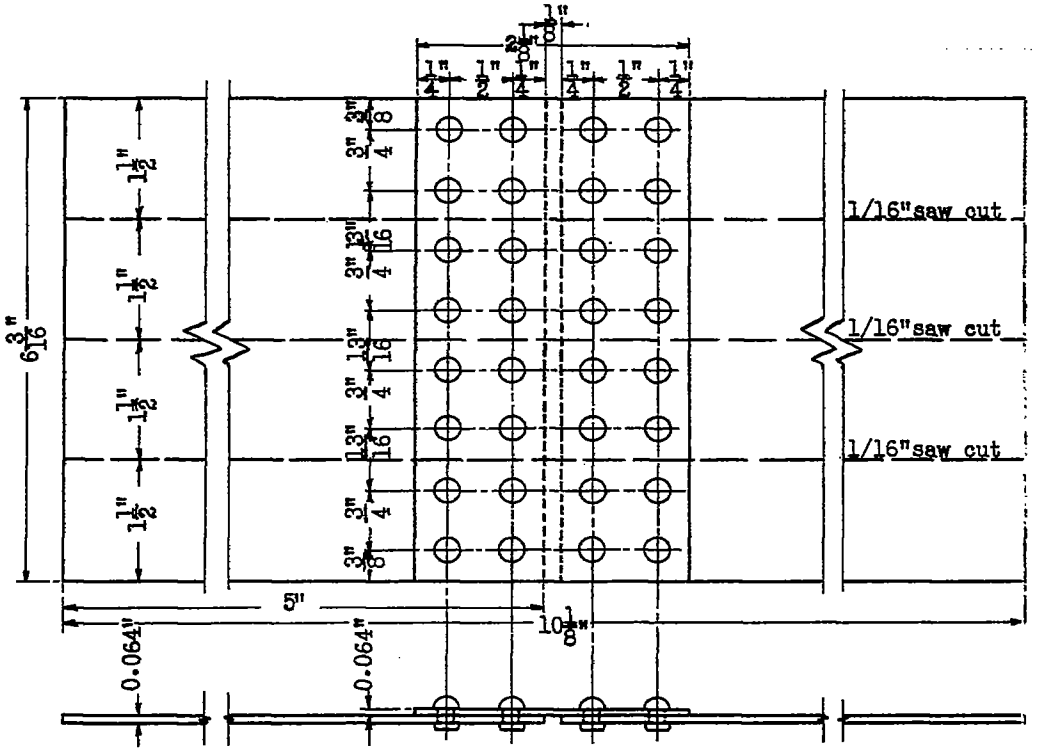
PANEL OF SINGLE SHEAR TEST SPECIMENS

Figure 1(f) 1/8" rivets
All Holes - No. 30 Drill (0.1285 in.)
Specimen Type 6



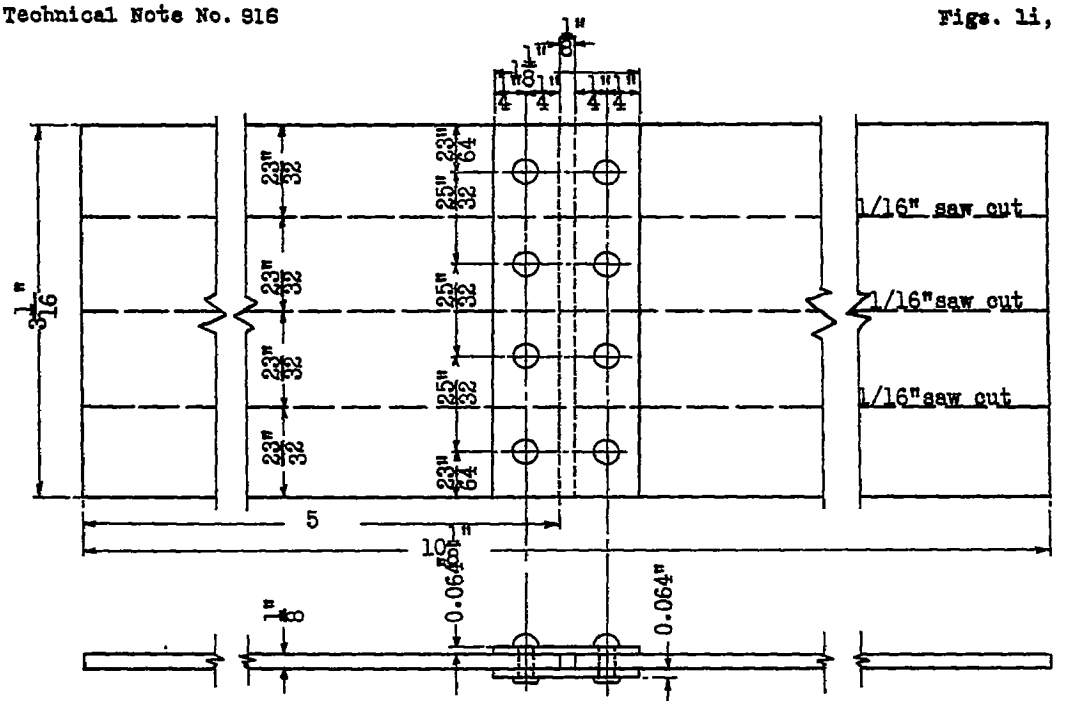
PANEL OF SINGLE SHEAR TEST SPECIMENS
1/8" rivets
All Holes - No. 30 Drill (0.1285 in.)
Specimen Type 7

Figure 1(g)



PANEL OF SINGLE SHEAR TEST SPECIMENS
1/8" rivets
All Holes - No. 30 Drill (0.1285 in.)
Specimen Type 8

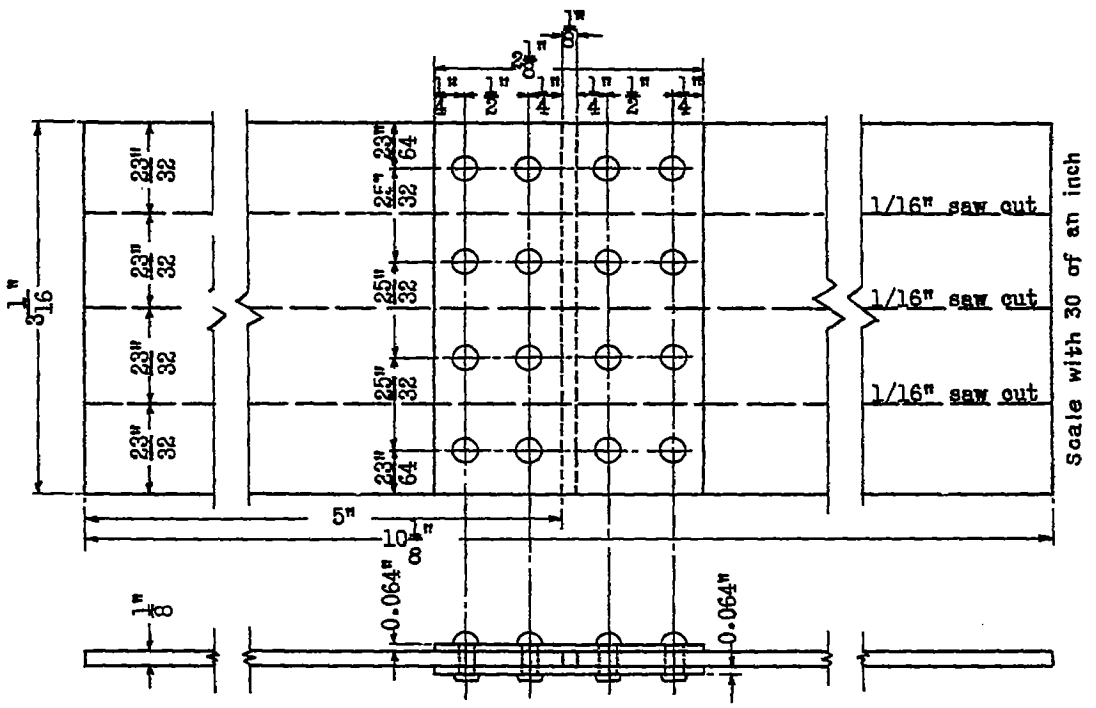
Figure 1(h)



PANEL OF DOUBLE SHEAR TEST SPECIMENS
1/8" rivets
All Holes - No. 30 Drill (0.1285 in.)

Figure 1(i)

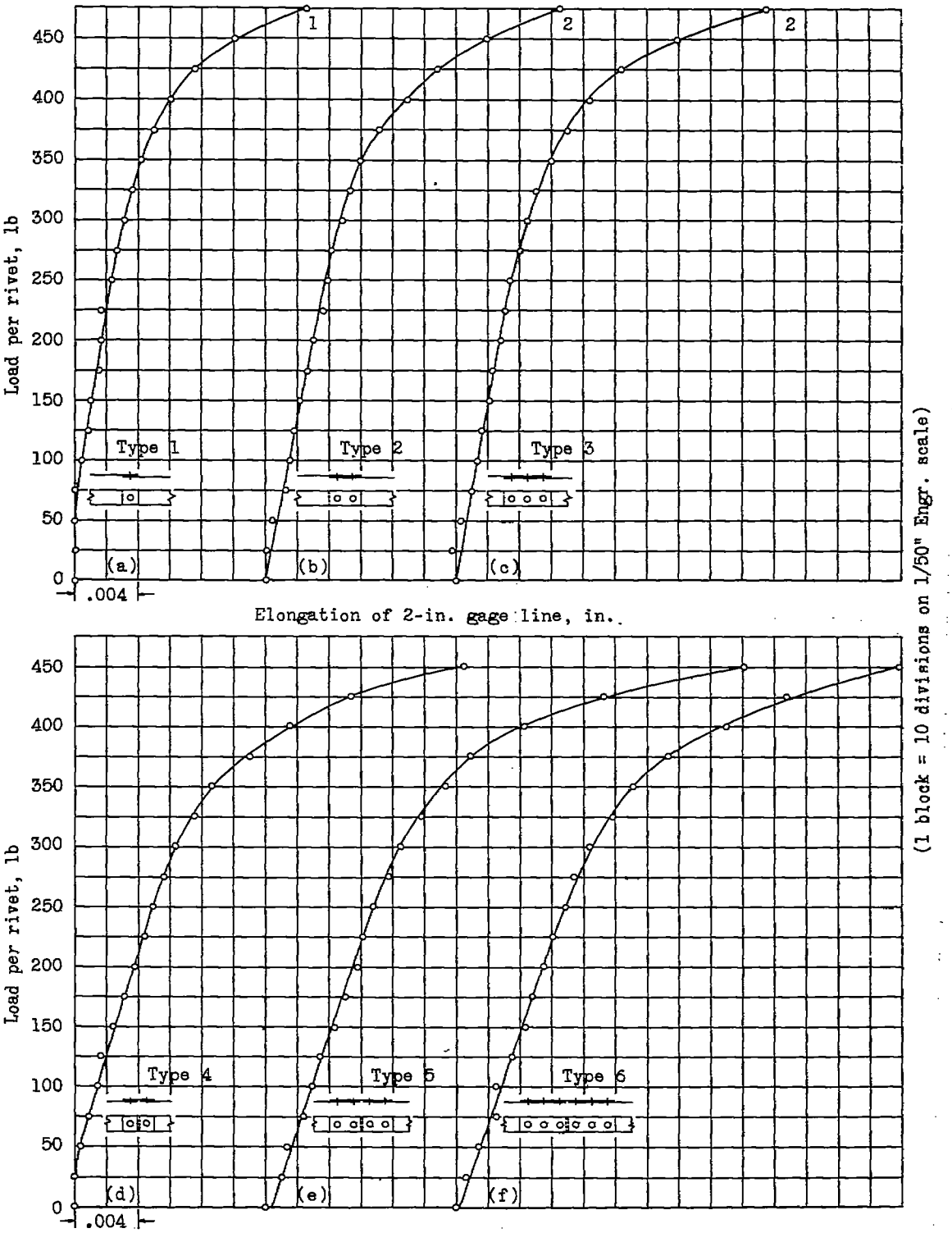
Specimen Type 9



PANEL OF DOUBLE SHEAR TEST SPECIMENS
1/8" rivets
All Holes - No. 30 Drill (0.1285 in.)

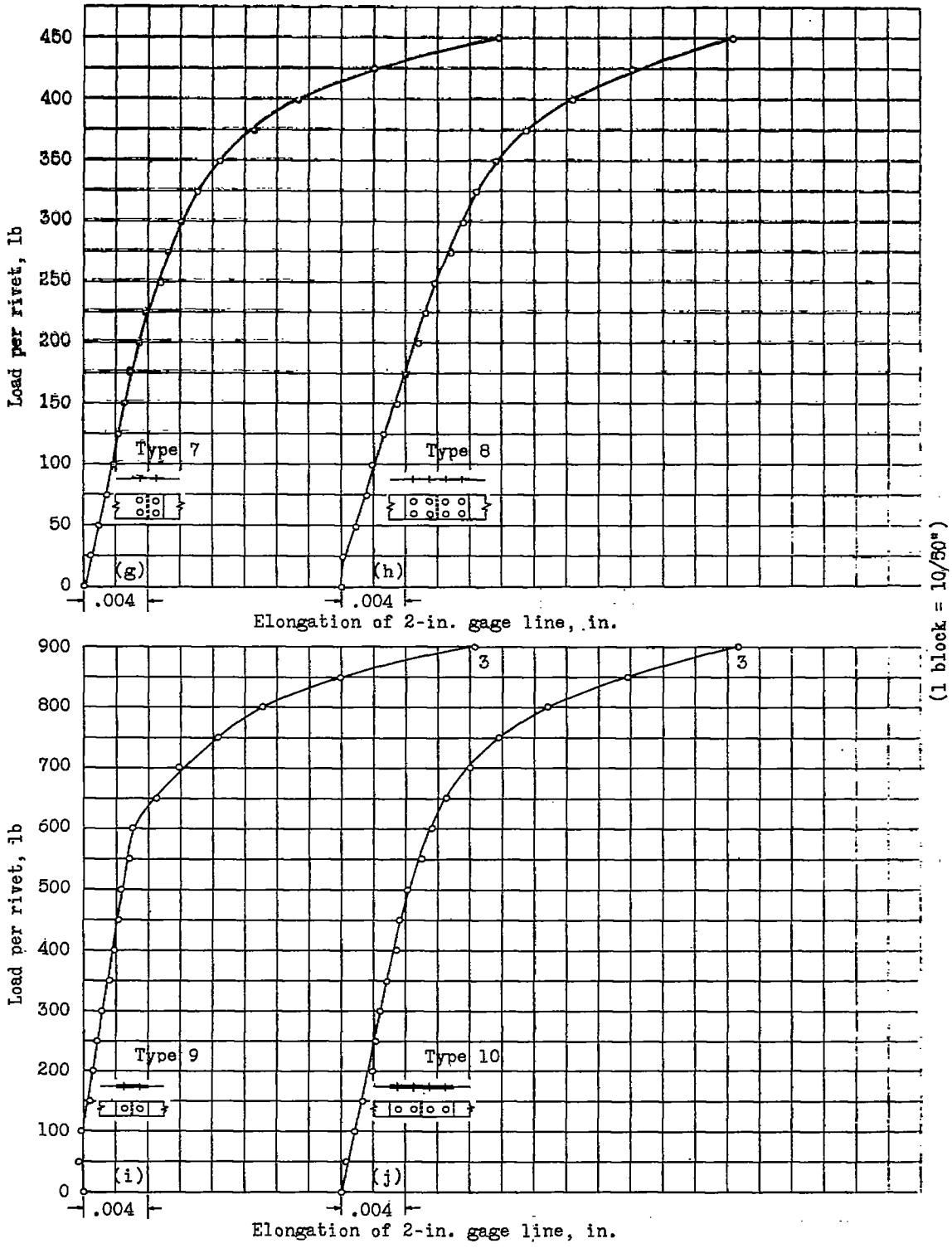
Figure 1(j)

Specimen Type 10



(a) Specimen type 1. (b) Specimen type 2. (c) Specimen type 3.
(d) Specimen type 4. (e) Specimen type 5. (f) Specimen type 6.

Figure 2 (a to j).- Load-slip curves for riveted joints. Except as noted, all points are averages of deformations of four specimens.



(g) Specimen type 7. (h) Specimen type 8. (i) Specimen type 9. (j) Specimen type 10.

Figure 2.- (Concluded).

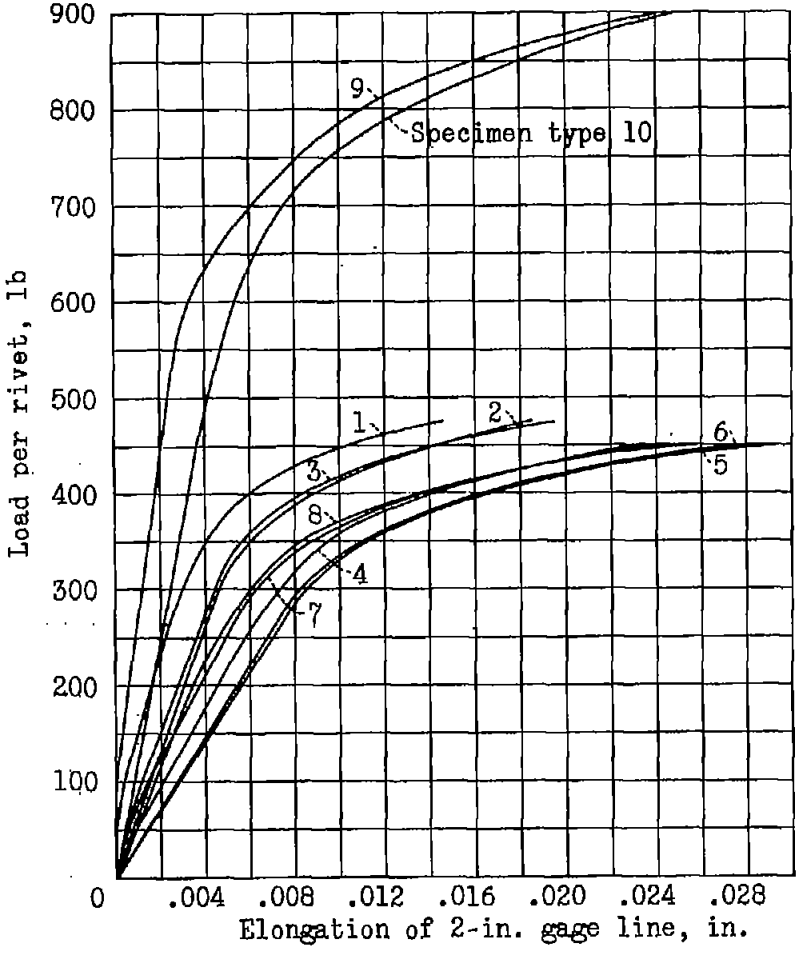


Figure 3.- Load-slip curves for various types of riveted joint.

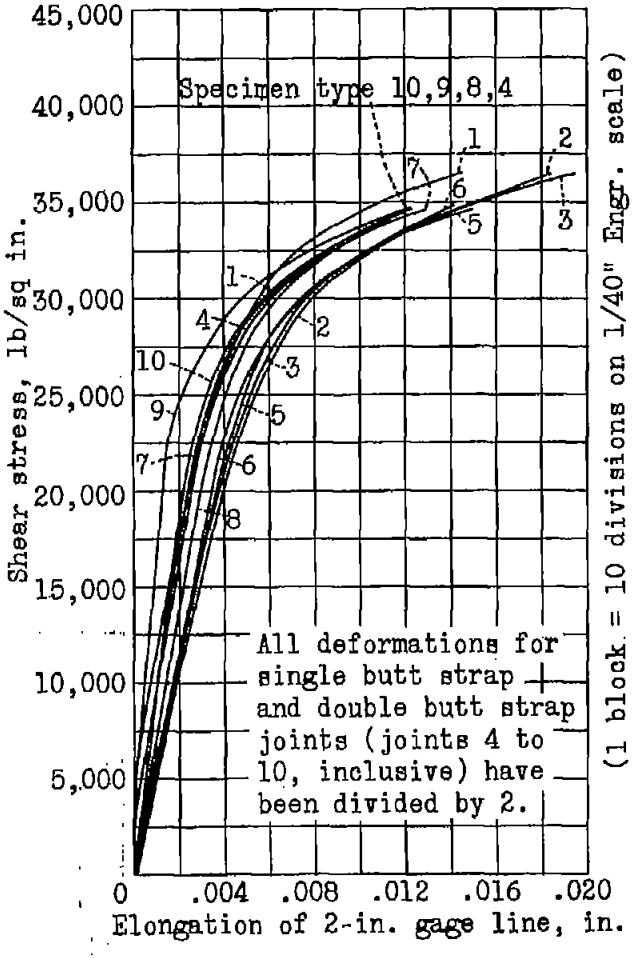


Figure 4.- Shear-stress-slip curves for various types of riveted joint.